Appendix B
Design and Specification Considerations for Fabrication and Erection

B-1. General Considerations

This appendix presents general design considerations and provides guidance on preparation of technical project specifications regarding fabrication and erection of tainter gates. Civil works guide specifications (CWGS) and military construction guide specifications (CEGS) may be used as a guide for preparing project specifications; however, the engineer must ensure that these specifications are tailored to reflect project specific requirements as required by Engineer Regulation (ER) 1110-2-8157.[1] Applicable CWGS and CEGS include CWGS 05913, CWGS 05101, CWGS 05502, CEGS 05120, CEGS 05090, and CEGS 05091. Engineer Manual (EM) 1110-2-2105 provides guidance for preparation of project technical specifications for steel used in hydraulic steel structures.

a. General specification requirements. Generally, the requirements for gate fabrication, installation, erection, and operational testing given in CWGS 05913 will apply. CWGS 05913 shall be edited to include project specific requirements consistent with guidance specified herein. Special considerations for critical or fracture critical members must be developed and specified. Although not included in CWGS 05913, bolted connections and framing members of American Society for Testing and Materials (ASTM) A 572 structural steel may be used in the construction of tainter gates. Where bolted construction and/or ASTM A 572 structural steel is specified, drawings and specifications shall be edited accordingly. In conformance with EM 1110-2-2105, project specifications should require full pretensioning of high-strength bolts for all bolted connections. Construction erection shall conform to requirements of American Institute of Steel Construction (AISC) S303, Sections 7 and 8.

b. Access and dimensional tolerance.

(1) Access design considerations. Members should be located and proportioned to provide sufficient access for workers and equipment required for fabrication, painting, and inspection. For example, there should be sufficient access to ensure that a welder has an unobstructed view of the weld root and sufficient space to apply quality welds with correct electrode angle. There should be sufficient access for sandblasting, painting, and inspection equipment and should be provisions (such as access hatches and safety railing) to provide an inspector access to frequently inspected areas.

(2) Specification tolerance requirements. The project specifications shall include provisions to ensure proper fabrication by conformance to American National Standard Institute (ANSI)/American Welding Society (AWS) D1.1 (1996) and AISC S303 (1992) requirements for fabrication and erection tolerances. (CWGS 05913 provision for alignment of elements that support skin plates is appropriate for welding of skin plate to supporting elements.) Provisions shall also be included to ensure proper gate operation and function. CWGS 05913 specifies tolerances for trunnion location and alignment and flatness of side-seal and sill plates. The specified tolerances for trunnion location are generally appropriate; however, these tolerances shall be determined by the engineer and should based on gate size and geometry.

[1] References are listed in Appendix A.

B-2. Shop Fabrication

In conformance with CWGS 05913, gates shall be shop fabricated. Where fabrication of the gate in separate segments is necessary for handling and shipping, segments shall be proportioned to facilitate assembly and to minimize the number of joints to be field-welded. Specifications shall include specific project dependent requirements on shop fabrication, preassembly, and field fabrication. Splices shall be at areas of low stress, and segments shall be of strength and stiffness to withstand forces imparted during shipping and erection (considering temporary supports and bracing). When gates must be fabricated in sections, the gate shall be preassembled in the shop and appropriate measure shall be taken to reproduce the assembly in the field. Splice locations and associated connection details shall be determined by the design engineer and shown on the contract drawings or determined by the contractor and approved by the contracting officer.

a. Forging and casting. Items to be forged or cast shall be indicated on the drawings. Specifications shall be edited to require that forging and casting for the prescribed material be done in accordance with the applicable ASTM standard. Recommended ASTM standards are provided in CWGS 05913 and Chapter 3.

b. General welding considerations. General welding requirements shall conform to ANSI/AWS D1.1 (1996) as provided in CWGS 05101 and CEGS 05090. For special circumstances not covered (i.e., welding stainless steel), the engineer shall develop the specific welding requirements and edit the specifications accordingly, or require approval of contractor developed procedures. Guidance on welding is provided in EM 1110-2-2105.

c. Complex details. Special considerations may be warranted for fabrication of complex welded details that join main structural members or that include thick plates subject to high constraint. The engineer shall develop necessary provisions for complex details considering the following guidance and edit the project plans and specifications (CWGS 05101 and CWGS 05913) accordingly.

(1) Vertical rib-to-horizontal girder connection design considerations. The welded vertical rib-to-horizontal girder connection shown in Figure B-1 is difficult to fabricate to provide optimum fracture resistance. Unfavorable conditions that are unavoidable include separation of rib and girder flange surfaces due to rib curvature, and intersection of vertical (transverse to girder flange) and horizontal (transverse to rib flange) welds. Additionally, relatively poor access for field welding exists since the clearance between girder flange and skin plate is limited by rib depth. Although this connection has been suitable in most projects, there have been several cases involving cracked and failed connections and special considerations are warranted. Historically, welded connections have been used and will continue to be used; however, with appropriate design, bolted connections are appropriate and have some advantages over welded connections.

(a) Welded connection considerations. The connection between the rib and girder is generally field-welded subsequent to fabrication of the skin plate assembly and girders. The designer shall ensure that rib depth is enough to provide adequate welding access for vertical welds. Due to the curvature of the vertical ribs, a flat joining of faying surfaces between the flanges of the girder and rib is not possible. Filler plates of thickness necessary to provide bearing between the curved rib flange and girder flange shall be included. A vertical seal weld of size necessary to fill the gap and cover the fill plate is generally provided. If the vertical weld is designed as a structural weld, then ANSI/AWS D1.1 (1996), Section 2.13, applies, and filler plates shall be selected such that the maximum gap between the girder flange and rib flange does not exceed 5 mm (3/16 in.). Generally, the vertical weld joining the edge of

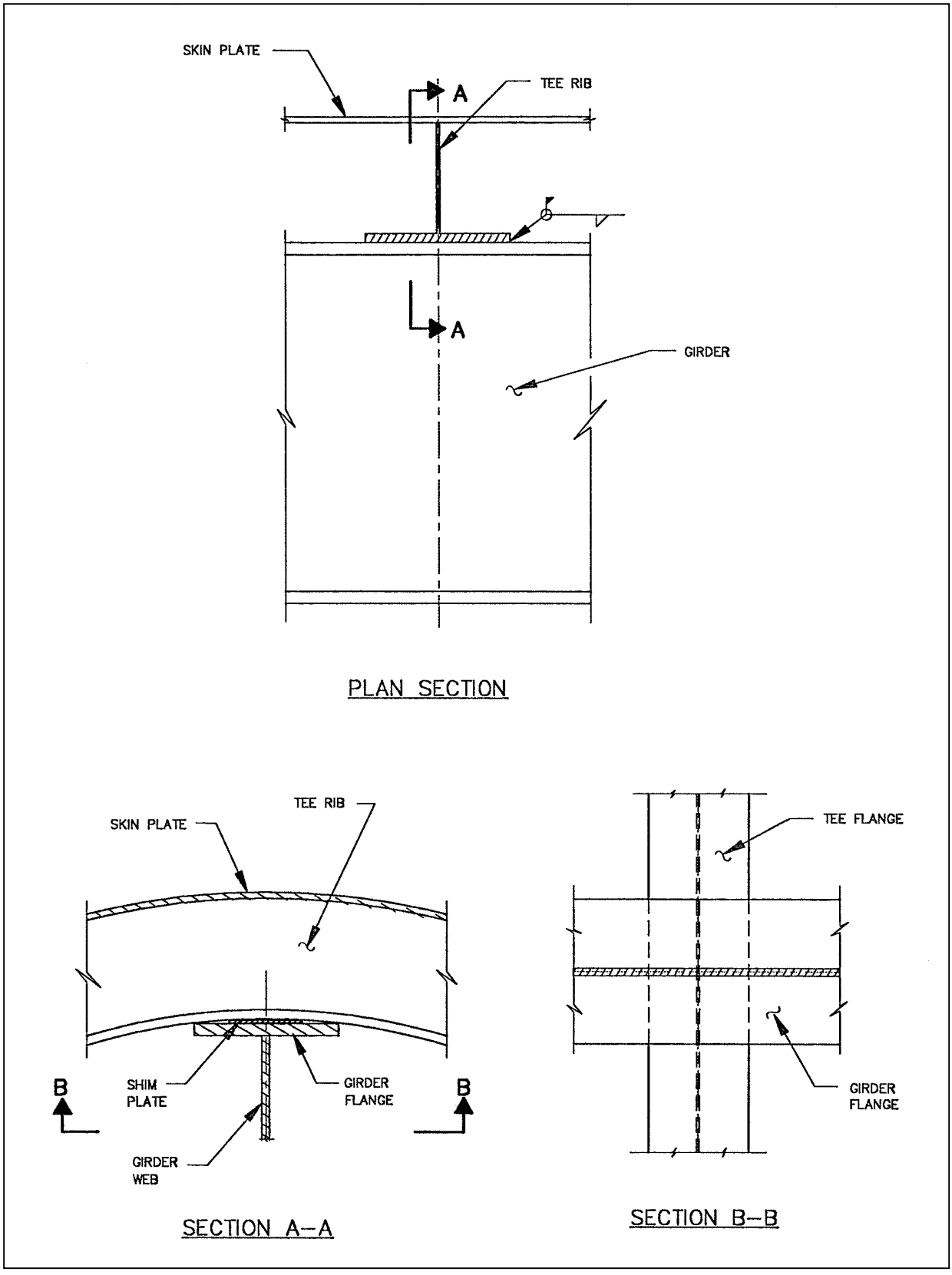

Figure B-1. Rib-to-girder connection (welded)

the rib flange to the girder flange is not a structural weld, since the horizontal weld is of adequate strength. Additionally, the horizontal and vertical welds are deposited on opposite sides of a common plane of contact to join the rib flange and girder flange. AISC (1994), Section J2.2, and ANSI/AWS D1.1 (1996), Section 2.4.7.2, require that welds deposited on opposite sides of a common plane of contact between two parts be interrupted at a corner common to both welds. This is not possible if the overlapping area is sealed. However, to minimize the adverse effects, the horizontal and vertical weld size shall be no larger than that necessary to provide a seal within 25.4 mm (1 in.) of their intersection.

(b) Bolted connection. The bolted connection alternative consists of an arrangement of four bolts joining the girder flange and rib flange (Figure B-2). The primary considerations in design are to select the appropriate bolt size to withstand the applied loads and to provide a solid bearing between the nut of the bolt and the bolt head. This can be accomplished with specially fabricated shims or by using a combination of shims and bevel washers. There must be adequate bearing to withstand full pre-tensioning of the bolts. The bolted connection alternative alleviates the problems associated with welding including intersecting welds and clearance between the girder flange and skin plate. The primary disadvantage is that the overlapping area between flanges of the rib and girder is not sealed from water intrusion.

(2) Full-penetration flange welds and weld access holes. At member intersections or splices where the flange of a rolled or built-up shape is welded with a full-penetration weld, weld access holes should be provided and detailed in compliance with ANSI/AWS D1.1 (1996), Section 5.17. Groove welds that do not have steel backing or back gouging are considered partial-penetration welds regardless of size, and backing is not possible without a weld access hole through the web. Additionally, without an access hole, an unfavorable residual stress condition exists where the flange and web welds intersect. This condition exists in the strut-to-girder connection, splices that may exist between the trunnion hub assembly flange plates and end frame struts, and at intersections of end frame members. At critical connections for intersecting members, the engineer shall show access hole requirements on the drawings or require approval of contractor submittals.

(3) Thick plate weldments. Weldments involving thick plates are particularly susceptible to cracking compared to those of thin plates. (A thick plate is generally considered to be 38 mm (1-1/2 in.) or greater in thickness.) The structural engineer shall develop a welding procedure (or require approval of a contractor developed procedure) for critical thick plate weldments and edit project specifications accordingly. General requirements for welding of thick plates are provided in EM 1110-2-2105. Trunnion yoke plates, trunnion bushing assembly, cable attachment brackets, steel trunnion girders, and built-up members generally include weldments with thick plates and/or high constraint. For the trunnion hub and yoke assemblies, plates are subject to large through-thickness stresses. The designer may require improved through-thickness properties by specifying steel with a maximum sulfur content of 0.01 percent and/or verification of resistance to lamellar tearing by testing in accordance with ASTM A 770/A 770M.

d. Trunnion. The engineer shall determine specific requirements for yokes, pins, and associated cladding, hubs, and bushings in accordance with guidance provided in Chapter 4 and edit project plans and specifications (CWGS 05913), accordingly.

e. Trunnion girder and anchorage. The engineer shall determine specific requirements for the trunnion girder and anchorage in accordance with guidance provided in Chapter 5 and Chapter 6 and edit project plans and specifications (CWGS 05913), accordingly.

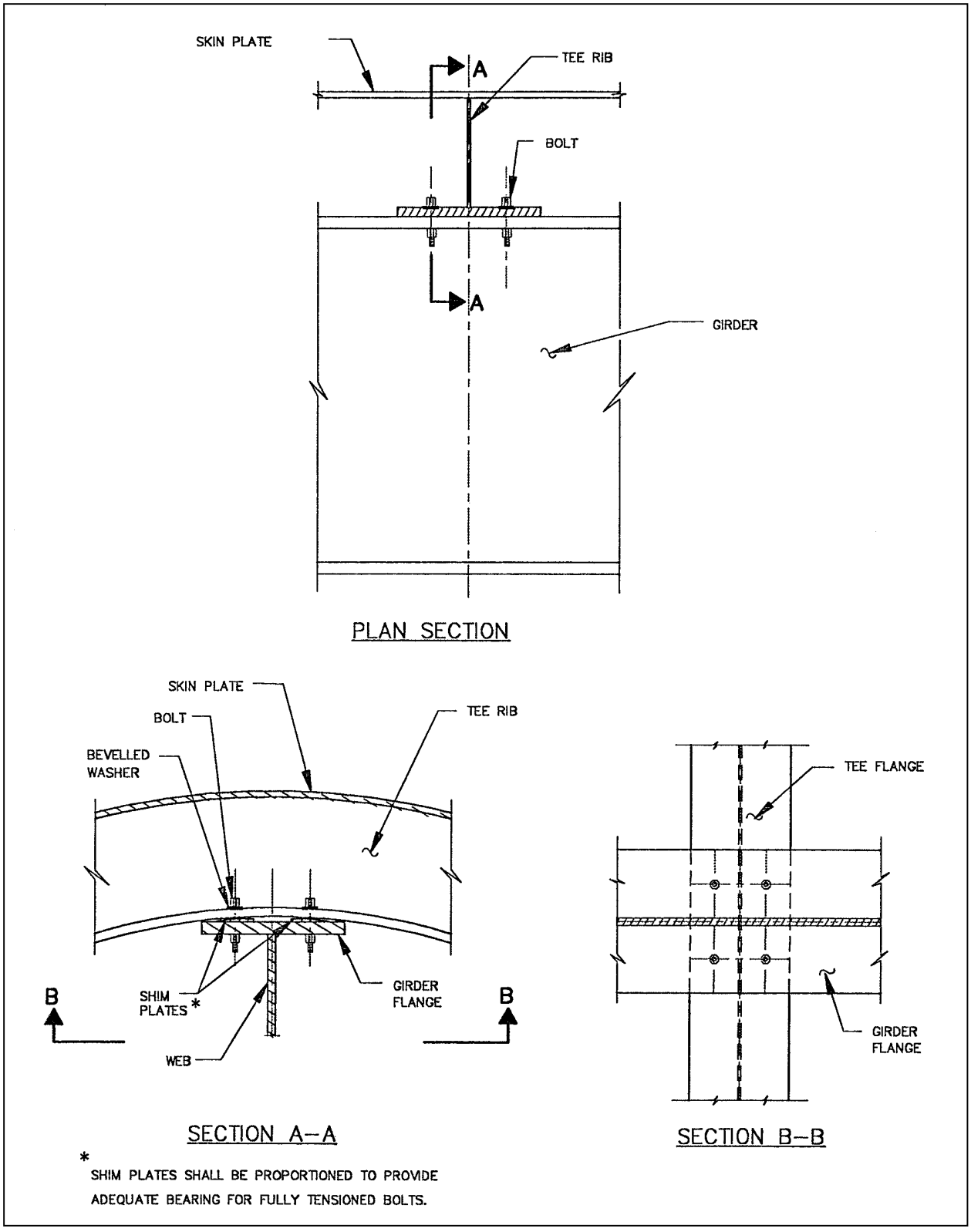

Figure B-2. Rib-to-girder connection (bolted)

f. Welding inspection requirements. CWGS 05101 shall be edited to specify contractor requirements for weld inspection considering general weld inspection requirements specified in EM 1110-2-2105 and the following:

(1) Prior to welding, thick (greater than 38 mm (1-1/2 in.)) plates of the trunnion hub and yoke assemblies that are subject to through-thickness weld residual stresses shall be examined in accordance with ASTM A435. In the vicinity of the weld, 100 percent of the plate surface shall be inspected.

(2) Critical groove welds including those in steel trunnion girders, at girder splice locations, at the end frame to girder connection, and trunnion weldments shall be inspected by ultrasonic inspection (UT) and/or radiographic inspection (R). Critical fillet welds are generally best inspected using penetrant inspection (PT) and/or magnetic particle inspection (MT). Critical welds and associated testing methods shall be determined by the engineer and shall be designated on the contract drawings.

(3) In accordance with ANSI/AASHTO/AWS D1.5 (1995), all tension butt welds of fracture critical members (FCM) shall be inspected using R and UT. All other tension groove welds in FCM shall be inspected by UT. The engineer shall determine all FCM and shall clearly designate all FCM and required nondestructive examination on the contract drawings.

B-3. Field Fabrication and Erection

Project specifications (CWGS 05101 and CWGS 05913) shall be edited to ensure conformance to fabrication, erection, and installation requirements specified herein. Specifications shall ensure that construction erection conforms to requirements of AISC S303 (1992), Sections 7 and 8, and the specifications shall require approval of contractor submitted erection plan prior to construction.

a. Gate assembly. Field assembly of the gate shall be conducted such that the assembled components are not over-stressed or unstable during assembly. The gate shall be assembled in conformance with the shop match markings using temporary supports that shall be removed after fabrication is completed. Prior to field welding and/or bolting of permanent connections, controlling dimensions and alignments shall be within specified tolerances. All field welding and associated nondestructive examination shall conform to requirements specified herein for shop fabrication. Skin plate welds shall be tested for water tightness after the gates are installed but prior to painting and mounting of seals, and disclosed leaks shall be sealed by appropriate means to be approved by the contracting officer.

b. Trunnion installation. Trunnion yokes and pins shall be installed and aligned in accordance with requirements provided in Chapter 4. For greased trunnion systems, the trunnion lubrication system lines shall be purged and filled with grease before the final connection to the gate. Bearing surfaces of trunnion pins and bushings shall be cleaned and coated with grease prior to installing the trunnion pins. For self-lubricating trunnion systems, bearing surfaces of trunnion pins and bushings shall be cleaned prior to installing gates.

c. Anchorage system and trunnion girder installation. Procedure for installation and anchorage of the trunnion girder shall conform to requirements of Chapters 5 and 6.

d. Protective coating and cathodic protection. The engineer shall determine the corrosion protection considering the project specific environment as discussed in Chapter 2, and guidance provided in Chapter 8 and CWGS 05913 shall be edited accordingly.